The Planters' Chronicle.

RECOGNISED AS THE OFFICIAL ORGAN OF THE U. P. A. S. I., INCORPORATED.

VOL. VIII. No. 14.] APRIL 5, 1913. [PRICE AS. 8.

THE U. P. A. S. I.

(INCORPORATED.)

Contents.

We are sorry to report that Lecanium Viride or Green Bug has appeared on a couple of estates near Saklaspur: and although every effort is being made, we hope with success, to stamp out the disease, under the capable supervision of Mr. Frattini, Scientific Assistant (Mysore), still Mr. Anstead, our Scientific Officer, has decided to visit and inspect these estates himself, and lend the aid of his more extended experience and advice to his assistant. He will not probably be away more than a week, but he feels it is of the greatest importance that he should make a personal inspection of the infected areas. This disease having once put in an appearance in Mysore, it is incombent on every Manager of a Coffee Estate to provide himself with one, if not more, knapsack sprayers to check the fell disease from the very beginning. No estate should be without one.

The Scientific Officer in this issue commences a report of his tour in the High Range, which is so interesting that it awakens a desire for more, which we trust will not be interrupted by his enforced, but very necessary visit to those infected estates near Saklaspur.

We are only able to publish a portion of the Proceedings of the Anamalai Planters' Association this week. The remainder will appear in next week's issue.

We are indebted to the *Bureau of Plant Industry* for a very interesting article on "Soil Bacteriology" as a factor in crop production which only increases our admiration towards those Scientific Agricultural Chemists who have set themselves to solve some of the wonders of nature. From no agriculturists can that tribute to them be witheld.

Lately from this Office some notices have been issued on behalf of Mr. Krumbiegel, Economic Botanist to the Government of Mysore, inviting application for fruit trees from Australia. It is to be hoped that advantage will be taken of this offer and that application will speedily be made. The larger the quantity ordered the cost will be much less.

Scientific Officer's Papers.

CXVII.—Report on a Tour in Travancore High Range.

From the 1st to 23rd of March I made a tour in the Travancore High Range. This was my first visit to this district and, thanks to the excellent arrangements made for me by the Honorary Secretary of the Kanan Devan Planters' Association and the transport facilities kindly afforded me by Mr. H. L. Pinches, I was able to see all the typical parts of the district and visit a large number of Estates.

The local conditions vary very considerably, and estates range from an elevation of 6,000 to 2,500 feet with an annual rainfall ranging from about 300 to 70 inches. A large number of crops are grown: the chief staple is Tea, but in addition to this Cardamoms are cultivated in the jungle, there is some Coffee, and a little Chinchona, while crops such as Camphor, Sisal, and Coca are being grown more or less experimentally. At the lower elevations there is a certain amount of Rubber, both Hevea and Ceará, and Fuel Trees are cultivated to a large extent.

Two types of land are planted; jungle which is naturally the best, and grass land, the latter being found to produce good Tea and to be suited to Fuel Trees, Sisal &c.

There are a large number of very interesting problems to be dealt with, and at two meetings of the District Planters' Association called while I was there I was able to discuss some of them in detail. In this Report I propose to deal with the more important of the problems of general interest somewhat at length.

TEA.

Cultivation, Soil Management, and Manuring Problems.

A number of different types of soil are to be found in the district, but all are soils of a loose friable texture which in the dry weather become very powdery. This causes one of the most outstanding difficulties, namely "dry wash". Much of the land planted in Tea is very steep and the slopes are at, or even beyond the 'angle of repose' for the soil in a dry state, and consequently the least disturbance causes the surface soil to slide down. The passage of the coolies plucking and weeding sets large quantities of it slipping down the slopes, and even the wind sets it in motion. The consequence is all the drains rapidly become blocked up, the roads are covered with soil, and each year when the rains come many tons of valuable soil are carried away in the rivers and lost.

This is all the more important since it is the surface soil which is denuded in this way. It is well-known that the fertility of a soil depends to a very large extent upon the process of nitrification going on in it. This nitrification is an oxidation process carried out by the agency of soil bacteria and the presence of air is necessary. Consequently the upper layers of the soil are the most fertile where the air can easily penetrate, and it is in these upper layers that the nitrifying bacteria are most plentiful and active. About 65% of the total nitrification occurs in the upper twelve inches of soil and little takes place below three feet depth. For this reason surface soils alone are highly fertile, and in the case of dry wash it is this valuable surface layer with its bacteria and readily available plant food which is constantly being lost. Tea is a deep-rooted plant, but its deep roots serve the purpose of supplying the plant with water more than anything else, and it feeds chiefly by means of its surface roots in the upper layers of the soil.

Many remedies have been suggested. In some places which I visited contour drains were being dug in new clearings with the object of saving the

soil. This is an expensive method and of limited value. A system of clean weeding is almost universally adopted in the district and this helps to increase the dry wash. I would advise experimental trials of the following methods of prevention. First of all the sickling of weeds on steep slopes so as to leave as many roots in the soil as possible to hold it up. In connection with this a special weed, a leguminous one for preference, of a close growing habit such as *Desmodium triflorum*, might be established and left. Attempts to do this have been made in some places, and the weed used for the purpose has generally been a clover like plant with a yellow flower, *Oxalis corniculata*, while *Cassia mimosoides* had been tried in another place. At the time of my visit it was difficult to find weeds of any kind, but probably there are many suitable for the purpose. The great objection to this method of control is the presence of leeches in the wet weather. It is possible, however, that leeches might be exterminated if it were worth while.

Some use might be made of the prunings, laying these across the slopes in alternate lines, or burying them with the brush part sticking out of the ground, with the object of holding up the soil and gradually forming natural terraces, and in connection with this I would suggest that, despite its obvious inconvenience, on steep slopes the tea should be originally lined along the contours across the slope instead of up and down it.

The problem is of sufficient importance to warrant experiment with these suggested methods on a large scale, and unless something is done to stop dry wash the life of the tea must be limited as will be shown when we come to the subject of manuring.

Cultivation and digging on slopes is to be deprecated and the soil should be left alone as much as possible. Where cultivation becomes necessary it will probably be better to apply manure rather than to dig in this particular type of soil.

Taking the district as a whole the tea has not yet been manured in any way and I found that most planters were anxious to know when this would become necessary or if it ever would. With the constant drain of surface soil the time is undoubtedly bound to come when it will be neceassry to apply manure if the present high yields per acre are to be maintained, and I should expect the tops of the slopes and the ridges from which the soil is most rapidly denuded to show the need of manures first.

What then are the first signs by means of which deterioration of tea may be recognised? The loss in yield is usually not the first sign, for this can often be maintained by closer plucking after deterioration has already set in. The first noticeable thing is as a rule the change in colour of the bushes. A healthy tea plant, growing vigorously, has a darker appearance than an unhealthy plant, and the leaves have what may be described for want of a better word an 'oily' appearance. At the beginning of the season the *whole surface* of healthy tea is growing, each shoot even in the outer parts of the bushes throws out a new growth which is vigorous and has oily looking dark green leaves. If the general colour of the tea is yellowish, if the difference in growth vigour at the outside of the bushes and in their centres is marked, if the shoots cease to grow and turn banjhi, then these are signs of decline and want of plant food in the soil. Tea showing these signs of decline is usually attacked by Red Rust and this is again a sign of all round weakness.

The appearance of the wood as well as the leaves and growth should also be watched. Nearly all the tea bushes have lichens and moss on their

stems but these only occupy a part of the surface; and it may be stated here that such growths are *not* parasites; they do not enter the tissues of the tea or take anything from the tea bush. They use the stems of the tea merely as a support and convenient resting place and they are known botanically as *epiphytes* in contradistinction to parasites and the utmost harm that they do is to partly choke the breathing pores of the bark, and if fungoid diseases are present act as places where spores can collect. These epiphytic growths will be found on most tea bushes, but they occupy only a *part* of the surface of the stems, but in unhealthy plants they spread over the *whole* surface of the stem giving the wood a white or greyish appearance which is generally described as 'hide-bound.' In this case too the leaf growth ceases to a large extent except from the younger wood at the top of the bushes, making the bush appear hollow. The wood is thin and whippy and white instead of thick, vigorous, and red.

These then are the most obvious signs of unhealthy deteriorating tea and when they are seen, one of two things has happened, either the bush is worn out or the soil is exhausted owing to incorrect treatment or lack of plant food; and the first thing to do is to make sure that the soil is in a good enough condition to enable the bushes to respond to treatment.

In the case of the soils in this district drainage and tilth are likely to be good owing to its natural friable nature, and in all probability if the signs described above appear in the tea it is plant food which is lacking.

When we come to consider the manurial requirements of tea in any particular soil it should be studied experimentally first on comparatively small areas. The first step to take before these experiments are begun is to have a chemical and mechanical analysis of the soil made upon which to base a manurial scheme, and it may not be out of place here to say a word or two about soil analyses in general.

When the relation of potash, phosphoric acid, and nitrogen more particularly to the growing plant was first discovered it was thought that the chemist had only to make an analysis of the soil to be able to make up a manurial formula, and this being applied any crop could be grown at will. It was quickly discovered, however, that the case was not so simple and that many factors came into play, some very difficult, and others almost, if not quite, impossible to determine in the laboratory. Of recent years the important part which micro-organisms play in the soil and their bearing upon fertility has been discovered and so the value of soil analyses has gradually been diminished until it is in danger of being altogether overlooked. Though a soil analysis cannot solve all the problems of manuring, nevertheless, it is of very great help when devising a manurial system and it more often than not indicates the broad lines upon which experiments can best be carried out.

I strongly advise, therefore, any planter who thinks that his tea may be nearing the time when it is advisable to apply manures to it to have analyses of his soils made and forward them to the Scientific Department for advice as to the kind of experiments to try.

No general rules can be laid down for manuring, but it may be safely said that where the deterioration is in growth and luxuriance the most important plant food is usually organic matter and nitrogen, while if deterioration in quality is noticeable phosphoric acid is generally the remedy.

(To be continued.)

RUDOLPH D. ANSTEAD.
Planting Expert.

DISTRICT PLANTERS' ASSOCIATIONS.

Anamalai Planters' Association.

Proceedings of the Tenth Annual General Meeting of the Anamalai Planters' Association, held at the Kalianapandal Bungalow at 2 p.m., on Thursday, 27th February, 1913.

1. *The Chairman's Address and Annual Report.*

Gentlemen,—It is usual at this Meeting for your Chairman to address you on the work that the General Committee has been carrying on for you during the past year—but as you have been fully informed, from our printed proceedings, of what has, from time to time, taken place—it is only necessary for me to draw your attention to a few of the more important subjects that are of general interest to us all.

Hospital.—It will be remembered that at our last Annual General Meeting held on the 12th of February, 1912 a Sub-Committee (consisting of Messrs. Duncan, Marsh and Simcock) was appointed to consider which block of land should be reserved for future public buildings and recreation ground; and that they were unanimous in recommending that a block of land, consisting of some 200 or 300 acres, now known as the "old" hospital site should be secured for this purpose. This is the block of land that was approved of for a hospital by both Mr. Gillman (the Collector at the time) and Major Long (the District Medical Officer) but when later on it was inspected by Mr. Hemmingway (our acting Collector), he pointed out that the site did not meet with his approval, as the land was surrounded by jungle—and it would be imposible to get a Medical Officer to live there alone by himself. He, at the same time, suggested a new site between Valparai and Monica—pointing out that this need only be a temporary place and that the hospital should be so constructed that it could be removed to the original site—whenever a township was started. The subject was gone into by us on 17th June, 1912 and although it was recognised that the site selected by Mr. Hemmingway was not in the least central for the district, and of very small area in extent, yet it was thought best to fall in with his views especially as there was, no doubt, that it might have been difficult to get a Medical Officer to live all alone on the site selected by us. Also that it was possible if we did not agree to the acting Collector's proposal it might delay matters and we might not eventually get a hospital at all.

Now, I gathered unofficially a short time ago, when in Coimbatore that it was possible that not only a Post Office but also a Travellers' Bungalow might be built by Government at a very early date. Now, Gentlemen, if there is any truth in this rumour, we should surely and strongly urge that they be built together with the hospital on the original site as selected by the planters themselves. I believe that we are all agreed that this spot is the most central (uncultivated area) for the district, as a whole, and that the future main road of the district will either pass right throught this block that we have selected for a township, or in any case within a hundred yards of it. If several buildings are constructed simultaneously, it would at once do away with its one and only drawback—*i.e. isolation*. There has unfortunately, or as it turns out possible fortunately, been delay, in doing much work—beyond a little felling on the new hospital site selected by Mr. Hemmingway, and I understand it is considered most unsafe to do any burning on the felled area before the rains have set in, so that no building operations can possibly be commenced anyhow until after the monsoon, even if then, which seems to me all the more reason why the original site as selected by us should be

reverted to. In the meantime our position with regard to our contribution towards the cost of the up-keep of the hospital is a very ambiguous one; for, we cannot very well subscribe to something that does not exist!! and the point also comes in as to, if the original site, as selected by the planters, is not adhered to, whether the guarantors of the fund are still liable for their subscription? The subject, Gentlemen, is a most important one to the district, which must be my excuse for going so fully into it and I would earnestly beg of you to give the matter your most serious consideration at this meeting.

Roads.—The up-keep of all the D. P. W. branch bandy-roads and bridle paths have been taken up, as from the 1st of January last, by the planters who are mostly interested in them, and I trust that this scheme may be beneficial to the district in general. It is to be given a year's trial and if successful will be continued.

Access to New Estates.—Several lines have been suggested, but I believe the owners of the new grants on the south of the Nadivar are unanimous in their opinion, that there are only two possible outlets. One *via* the Castlecroft Estate and the other *via* the "old" hospital site—whichever route is decided upon, it will at once turn to Paralai—Castlecroft branch bandy-road, anyhow, as far as the 4th mile—into the main road of the district, and for its whole length, if the Castlecroft estate line is taken. The line to be adopted should not be definitely decided upon, Gentlemen, until the various traces have been completed; but the matter should be gone into at this meeting, for, it is of a very urgent nature, to all the new applicants, who must have a line of communication with the Government road as soon as possible. And whilst on this subject it might be as well for me to draw your attention to the Boards' Proceedings. Forest No. 182 dated 15th October, 1912 informing the planters that "they must make their own arrangements to obtain access to the main routes of communication and that Government's aid, in case of compulsory acquisition, can be rendered only under certain specified conditions." It is true, Gentlemen, that we quite understand that Government was under no obligation to *cut* roads for us to our new applications; but that they should give us no *right-of-way* or access to same, seems to be absolutely preposterous and absurd. The question is what are we to do? I suggest that we address Government direct on the subject, as it appears to me our position has not been properly explained to them. I do not think it has been sufficiently clearly pointed out, that in many cases, Government bridle-paths actually extend to the new applications, and that no further rights-of-way will be required in these cases, that all we ask for is that Government reserve outlets for us where this is not the case—and that we belive in almost every—if not every—case, rights-of-way can be secured, on unfelled land, the majority, if not all of which, has only recently been granted to the planters, on the distinct understanding that the said "grants are subject to the reservation of areas for such purposes, viz., public buildings, general convenience) the areas of the land thus reserved, being deducted from the areas granted."—*Vide* D. F. O.'s letter dated 22-1-12 No. 585 sub. of 10. I have brought this before you, as it seems to me very important and that the matter should be dealt with at the same time as we are dealing with "Access to New Estates."

Checking of Fertiliser Guarantees.—The Scientific Department of the U.P.A.S.I. undertook at their last Annual Meeting to verify the guaranteed analysis of manures sold by the different firms. I have myself so far sent three samples of manures to be checked by the Planting Expert with the following results:—

Description of Manure.	Guaranteed Analyses.	Actual Analysis.
Sulphate of Potash ...	48—50% pure Potash	48·72
Concentrated Superphospates..	42—45% Phosporic acid	44·31
The following Mixture— 25 tons of Fish 5 tons Neem Poonac	4·82 Nitrogen 3·33 Phosphoric acid	4·18 Nitrogen 61·21 Organic matter. 4·59 Phosphoric acid. 24·14 Sand.

It will, therefore, be seen that the guarantees so far as Sulphate of Potash and concentrated Superphosphates have been well maintained and that in the case of the *Mixture* the Nitrogen was short but that the shortage was well made up by the excess of Phosphoric Acid. The point, however, about this last analysis is, the large percentage of sand; which shows I have had to transport the whole way from Calicut to the Estate 24% of absolutely useless seashore sand. I think, under the circumstances, we should try and insist upon the suppliers guaranteeing a limited amount of sand. I know our Planting Expert is all for this. and I believe the matter only requires pressing to gain what we desire. All the manures were supplied by Messrs. Peirce, Leslie & Co., Ltd.

I trust you will not think I have intruded upon your time by bringing these analyses to your notice. They should, I think, be of great interest and value to the whole planting community.

The Cooly shelters on the Ghat Road have not yet been started and it looks as if another monsoon will pass without these very necessary buildings having been provided.

We, months ago, selected Mr. Duncan as our *Magistrate for the District* but I am not aware that Government has appointed him yet.

Brake Logs on Carts.—The Acting District Forest Officer suggested to me the other day that we got printed passes for this purpose and it seems quite reasonable that we fall in with his request.

Post Office for the District.—Our Honorary Secretary informs me that his letters to the Postmaster-General on this subject have merely been acknowledged; but in view of the fact that it is contemplated building a Post Office, it appears to me possible that the subject is being dealt with by the heads of the Revenue and Postal Departments direct, and I would suggest that our Honorary Secretary write to the Collector asking him if this is the case, and if not, to request the Collector to very kindly use his influence with the Postal Department to get a Post Office constructed at a very early date.

Labour.—You all know that at the U. P. A. S. I. Annual Meeting your delegates agreed to pay the higher rate of subscription to our parent Association, tentatively for one year on the distinct understanding that some united action as regards labour problems be brought forward and adopted at the next Annual Meeting. From what is being recorded in the *Planters' Chronicle* there seems little chance of this being done—and if this is not done it then remains for you to decide if we shall not do better by reverting to our old subscription to our parent Association and using the difference in the subscription. in some way beneficial to our own labour troubles.

The Wire Rope-way and Electric Scheme.—Is on the Agenda paper and should be carefully gone into—it may make the very greatest difference to our transport in the future.

I now beg to place my resignation in your hands and in doing so, I have to thank our Honorary Secetary and our Committee for so willingly helping me in carrying out my duties as your Chairman during the past year.

(Signed) G. A. MARSH.

(To be continued.)

SELECTED CUTTINGS.

Soil Bacteriology as a Factor in Crop Production.

By Karl F. Kellerman, *Physiologist in Charge of Soil-Bacteriology and Plant Nutrition Investigations.*

Importance of Soil Bacteriology.

This day and generation are in the grasp of the invisible, the things infinitesimal, the things minute. The physician and the engineer have learned that they can battle with the complex conditions of to-day only by understanding a wealth of microscopic detail that formerly would have been considered ridiculous. These two professions have now joined with biology in recognising the microscope as a necessity. It is not surprising, therefore, that the most important profession in the world, that of farming, should awaken to the desire of comprehending and controlling the tremendous, although imperceptible forces which may enrich or ruin fields and crops.

It no longer thrills an audience to say that soil is a living thing; it is either a trite remark, a common place relegated to the shelves as uninteresting, or it is a statement quoted impressively to explain everything in soil fertility. Both attitudes are unfair to this new science. Real progress is slow, and there are good reasons for asking the farmer to maintain a deep interest in the unseen population of the fields and to beware of dogmatic explanations unsupported by properly marshalled facts. The average mind is more than willing to believe a fairy tale, but unquestioning belief in hasty conclusions is more injurious to future progress than temporary lack of interest or appreciation.

Most readers of modern agricultural literature are familiar with the generalization that but for the various agents of decay the world would, in a very short time, become uninhabitable. It is through the constant disintegration and decay of dead plants and animals that fertile soils are regenerated and that the processes of growth of plants and animals can continue. Only during the last half century has the science of bacteriology shown how remarkable is this transmutation of the dead plants and animals back to soil. Bacteria themselves are plants. They form the simplest group of the fungi, or plants that are lacking in chlorophyll. They are exceedingly minute; the majority are not more than one one-hundred-thousandth of an inch in diameter, and it is believed that some bacteria exist which are too small to be seen even with the aid of the most powerful microscope. In spite of their small size, however, they are concerned with every phase of our daily life and by their incredible numbers and ceaseless activity overcome their apparent insignificance. Bacteria cause diseases, make milk sour, and in many ways are most troublesome. In spite of the evil that some species of this group of plants cause, however, other species, and even some of the troublesome species, under different conditions, are beneficial.

Classes of Soil Bacteria.

The bacteria of the soil are chiefly of the beneficial types. They occur in almost infinite numbers, a fertile soil having from 15,000,000 to 300,000,000 to the ounce. Their functions and value are variable, both because the kinds of bacteria differ in soils and because any given species may vary physiologically within certain limits according to environmental conditions. The moisture, the temperature, the degree of pulverization, the rock formation, or the geological history of the soil, the aeration, the drainage etc., are all factors which partly determine the action of soil bacteria; and perhaps more important than any of these limiting conditions is

the effect of one kind of organism upon those with which it is closely associated, or more broadly speaking, the effect of the associative or competitive action of the various groups of micro-organisms which act and react upon each other.

In outlining briefly the relation of soil bacteriology to crop production it is simpler to consider the subject from the standpoint of the bacteriologist and refer to groups of organisms more or less well-known that perform different functions in maintaing the fertility of farm soils. These groups taken in their entirety include practically all of the known types of decomposition and synthesis which take place in the soil. They include organisms which produce hydrogen-sulphid gas, indol, mercaptan, and other substances of this character whose importance in agriculture has yet to be demonstrated and need not be considered at this time. The chief groups and the order in which they will be discussed are the carbohydrate fermenters, which change starch, sugar, cellulose, etc.; the ammonifiers, which decompose nitrogenous compounds and form ammonia; the nitrifiers, which oxidize ammonia to nitrite and nitrite to nitrate; the denitrifiers, which reduce nitrate to nitrite and sometimes to free nitrogen gas; and the nitrogen fixers, which "fix" or combine the free nitrogen gas of the air with other substances to form proteids.

Carbohydrate-Fermenting Bacteria.

The group of organisms fermenting carbohydrates, such as sugar, starch, and especially cellulose, which is the substance forming the firm or fibrous portions of plants, has many representatives, but their functions and their relations to crop plants are in most cases not well understood. It is known, of course, that many species of bacteria will ferment the different sugars, forming some organic acid and frequently carbon dioxid and hydrogen or carbon dioxid and methane. It is highly probable that the constant production of these gases, in minute quantities it is true, in the chemically powerful condition of the nascent or freshly liberated gas exerts a much greater influence in soil weathering and the solution of plant food from small particles of minerals than any of the much-discussed agencies of the plant roots themselves. Both the carbon dioxid and the organic acids produced by these organisms are presumed to be of importance in controlling the availability of phosphates. No satisfactory methods of controlling this action have been developed, however, and no accurate estimate of this function has been possible.

The most resistant carbohydrate found in the soil and the type of carbohydrate which is most important because of the enormous quantities added to soils annually is plant fibre or cellulose. This is a substance so resistant to even moderately strong acids and alkalis that it appears at first glance almost indestructible. Obviously, however, active agents for cellulose destruction must be constantly operating; the decay of wheat stubble, of cornstalks, and of green manure turned under, as well as the rapid rotting of dead trees, are perhaps the best illustrations of this. It should be noted that humus has long been recognised as an essential constituent of a fertile soil, and more recently it has become apparent that many of the processes constantly going on in the soil which result in the formation of available plant food are controlled in a large measure by the quantity and quality of the humus compounds. In the formation of these compounds the cellulose, which is decomposed in the soil in such large quantities, must play a prominent role.

Extensive studies in our laboratory during the past two years have shown that there are numerous organisms endowed with the power of

actively fermenting cellulose. The cellulose is made soluble and becomes available as carbohydrate food for other organisms, especially the nitrogen fixers, which will be referred to later. There is another phase of cellulose destruction which appears to be of great economic importance from the soil-fertility standpoint, and that is the action of filamentous fungi. Several investigators from time to time have found one or more species of molds to which they have attributed the power to dissolve cellulose, but no systematic attempt has been made to determine the extent of this phase of cellulose destruction. It appears, however, that cellulose destruction by molds is as important, if not more important, than its destruction by bacteria. There are at least 75 species of cellulose-destroying molds representing a large number of genera, including such common forms as *Aspergillus*, *Fusarium*, and *Penicillium*, which is the green mold so often seen on fruit and moist hay. The enormous quantity of cellulose available in the soil and the tremendous energy that can be developed by bacteria in breaking up the cellulose into simpler ferments make it seem at least possible that the maintenance of a high degree of fertility depends more upon the presence in the soil of the proper flora for decomposing the cellulose than upon the existence of any group. It should be remembered that this accumulation of carbohydrate food the source of energy for so many soil processes, is due to the fact that chlorophyll, the green colouring matter of the leaves of plants, in some manner as yet unexplained, enables the plants to absorb the carbon dioxid of the atmosphere and to utilize the energy of the sunlight to transform this carbon dioxid and the water of the plant sap into carbohydrates. The synthesis of carbohydrates is logically the most fundamental question of plant physiology, for this great quantity of potential energy is chiefly responsible for the continuance of plant and animal life.

Ammonia Forming Bacteria.

There are many species of bacteria very widely distributed in nature which break down proteid compounds, forming ammonia together with other decomposition products. These ammonifiers, indeed, comprise what is numerically, perhaps the largest, group of soil organisms. It was formerly supposed that crop plants were unable to assimilate nitrogen in the form of ammonia. The production of ammonia by bacteria was, therefore, regarded as merely a preliminary step in the preparation of suitable plant food. More recent investigations show clearly that many crop plants, especially cereals, are able to assimilate ammonia nitrogen. The ammonifiers, therefore, do prepare a suitable food for crop plants, and because of the rapidity of their action and because of the enormous number of them that are found in all soils we shall probably have to consider this the most important group of bacteria. The fact that they are widely distributed, however, makes them somewhat less interesting from the standpoint of controlling fertility, since it is doubtful whether conditions obtain in any agricultural region where these bacteria are not present in sufficient numbers to transform rapidly into ammonia whatever proteid nitrogen may be turned into the soil, provided conditions for bacterial growth are favourable. In this connection it is interesting to note that the Subtilis group, a sub-division of the group of ammonifiers comprising four or five distinct species, occurs probably in every cultivated country. It has been found in every country where any attempt has been made to isolate these species. The products formed by the various species of bacteria in the ammonifying group, in addition to the ammonia formed from the proteid nitrogen, are not well-known. It is, therefore, a possibility that some of these bacteria may produce substances injurious to the growth of crop plants. The so-called soil toxins, which may or may not be important

factors in limiting the development or continued cultivation of certain crops, may be produced by these bacteria; there is as yet, however, no satisfactory evidence that such is the case.

Nitrifying Bacteria.

The nitrifying bacteria are in reality two groups of organisms. The first group when supplied with mineral plant food and with ammonia nitrogen transforms the ammonia into nitrite. This group, which formerly was considered to consist of a few very highly specialised organisms, is now known to number many species, most of which, however, have the power of making the transformation of ammonia to nitrite only to a moderate degree. The large number of organisms having this power makes it seem probable that usually they may be more important than the few species that are more active and also are more seldom found. The second group of nitrifying bacteria is able to further oxidize the nitrogen in the form of nitrites to nitrate nitrogen. Nitrate nitrogen is the form of nitrogen usually considered to be of the highest value as plant food, while nitrite nitrogen, except in very minute quantities, is an actual poison to crops. This specialized group of bacteria, therefore, which is able to feed on nitrate nitrogen and as fast as it is produced transform it into desirable food, is of extreme importance in all cultivated soils. Like the ammonifying bacteria, however, the bacteria of this group also are widely distributed and usually are present in sufficient numbers to perform their proper functions. They develop best in soils that are kept in good tilth, and usually grow very sparingly, if at all, in water-logged acid soils, and but sparingly in the fine-grained clays and gumbos that are almost impervious to the air.

Denitrifying Bacteria.

The denitrifying bacteria, many of which are also ammonifying bacteria, are those which have the power almost diametrically opposed to that of the two groups just described. These organisms transform nitrate into nitrite, perhaps also into ammonia, and certainly many of them are capable of breaking up the molecule entirely and giving off free nitrogen gas. This group of organisms if functioning in this manner constantly would soon destroy the most fertile land, but although these organisms are found generally, they are not usually very plentiful and they do not become active denitrifiers unless afforded certain definite conditions for growth. The requirements of different species of the denitrifying group vary considerably; most of them will transform nitrate nitrogen into nitrite if organic material, such as beef broth or plant extracts, or even manure, be supplied them together with nitrate nitrogen. This fact illustrates the danger of applying nitrate fertilizers and manure simultaneously to a crop. Especially if the soil is moist or water-logged at the time there ensues a rapid development of nitrites with consequent injury to the crop. If nitrates and manure are to be applied to a given field, the manure should be applied weeks or, preferably, months in advance, in order to allow the preliminary decomposition of the proteid compounds in the manure to proceed to a point where they will no longer be food for denitrifying bacteria.

Nitrogen-Fixing Bacteria.

The nitrogen-fixing bacteria are those which have the power of combining the atmospheric nitrogen with their other food materials and forming proteid nitrogen. Their activity can be enhanced by the improvement of the soil tilth, and sometimes also by the addition of carbohydrates, such as sugar and molasses. It is probable, however, that cellulose which has been decomposed to some soluble form is as good a food as any of the sugars produced commercially. Since the development of these free-living, nitrogen-

fixing bacteria is presumed to be largely responsible for the continued fertility of agricultural land and since it is probable that these bacteria are the chief cause of the undiminished fertility of the lands of the intermountain district in the northwest, where continuous grain cropping has produced no apparent diminution in soil nitrogen, both the importance of this group of bacteria and the probable correlation of the development of nitrogen-fixing bacteria with cellulose-dissolving bacteria are obvious.

Nodule-Forming Bacteria.

An important sub-division of nitrogen-fixing bacteria and one which is perhaps better known than any other group of soil bacteria is the nodule-forming bacteria of the legumes. These bacteria when associated with the roots of the leguminous plants and a few non-leguminous plants form nodules upon the roots which are capable of using as food large quantities of atmospheric nitrogen. Since the study of the nitrogen, accumulating power of legumes bearing root nodules deals with a definite and comparatively simple relation of a single type of organism to a single type of plant, it has been possible to develop these investigations upon a pure-culture basis; in other words, it has been possible to isolate the nitrogen-fixing organism from nodules of leguminous plants and with these cultures produce nodules upon other plants of the same species in different localities. Owing to the fact that different legumes are constantly being introduced into agricultural regions, the importance of being able to disseminate the nodule-forming bacteria is obvious. For many types of legumes this is desirable, not only from the standpoint of making the crop a better nitrogen-fixer and better soil renovator, but because for most legumes the crop is actually larger when properly inoculated. Pure-culture inoculation is less certain than inoculation by means of soil from old, well-inoculated fields, though, of course, it is free from the danger of introducing troublesome weed seeds or plant diseases.

A casual review of the present status of soil bacteriology shows that it is a subject of almost bewildering complexity, but very intimately associated with the normal physiology of all crop plants. By learning what functions must be performed in the soil and by studying each group of organisms that has a measurable function, we believe that we can learn how to enhance the desirable activities of the living soil and to check the undesirable ones. We may never find another relationship so simple as that existing between the legume crop and the nodule bacillus or one which we can control so simply from a central laboratory; but surely a thorough comprehension of what happens in the soil will teach us how to maintain the fertility of the soil more surely than blind and rather purposeless experimentation. The great majority of plant tests of fertilizers illustrate the impossibility of satisfactory deductions from experiments entirely upon an empirical basis. We must deal in aeons and not in generations if agricultural science is to be advanced by the cut-and-dry method.—*Bureau Plant Industry.*

New Zealand Prohibition against Crown-Gall.

The New Zealand Government has issued a proclamation prohibiting the introduction into the Dominion of any fruit or plants infected with the disease known as root-knot, hairy-root or crown-gall (Bacterium tumefaciens). If any plant, fruit, &c., affected is introduced or shipped to New Zealand, it and any wrappings, &c., will be reshipped or destroyed at port of entry. Reshipment, however, is conditional on the approval of the Inspector, and in the event of destruction, the fees for such destruction are payable by the person in charge of the consignment.—*The Gardeners' Chronicle.*